CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-102

December 15, 1980

1. Name of fault.

Hayward fault (Oakland segment).

2. Location of fault.

Alameda County, Oakland West and Oakland East 7.5-minute quadrangles (see Figure 1).

3. Reason for evaluation.

Part of a ten-year program to evaluate and revise Alquist-Priolo Special Studies Zones maps (see Hart, 1980). The existing maps are included in this report as Figures 2A and 2B.

4. List of references.*

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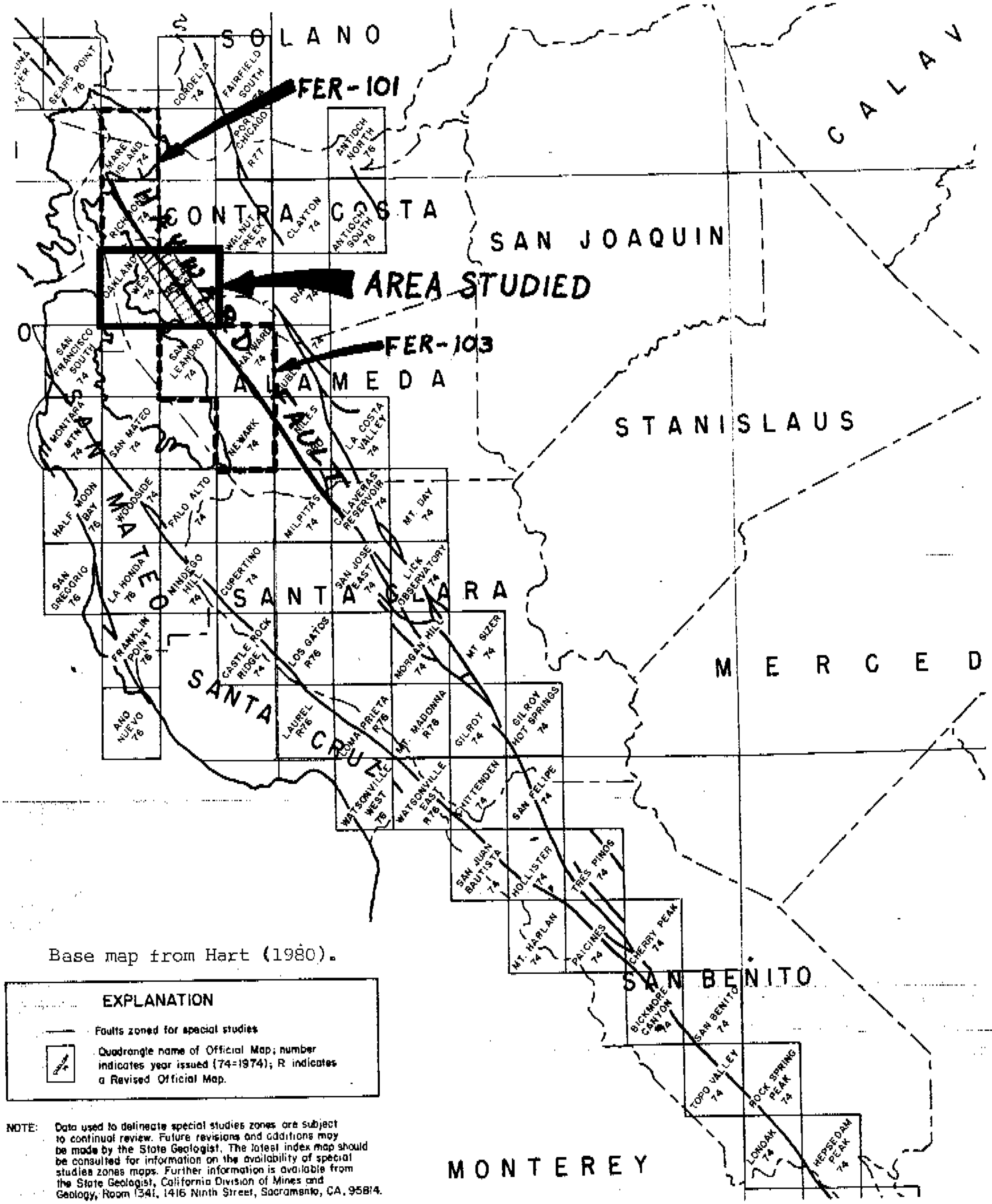
*References cited include supplements and amendments to the cited reports, and review comments by the local jurisdication's geologist. Also included are Alquist-Priolo file numbers (e.g., AP#249) and informal consulting report file numbers (e.g., C#441) assigned by CDMG.

Figure 1. Location of Oakland East and Oakland West quadrangles.



Base map from Hart (1980).

EXPLANATION

Faults zoned for special studies

Quadrangle name of Official Map; number indicates year issued (74=1974); R indicates a Revised Official Map.

NOTE: Data used to delineate special studies zones are subject to continual review. Future revisions and additions may be made by the State Geologist. The latest index map should be consulted for information on the availability of special studies zones maps. Further information is available from the State Geologist, California Division of Mines and Geology, Room 1341, 1416 Ninth Street, Sacramento, CA, 95814.

Scale 1:1,000,000

1 inch equals approximately 16 miles

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6

5. Summary of available data.

The Hayward fault is a right-lateral, strike-slip fault which extends from Point Pinole Regional Shoreline southward to Milpitas and beyond. Part of the San Andreas fault system, the connection of the Hayward with the Calaveras fault, and eventually, the San Andreas fault, has puzzled many geologists for the last two decades or more. Just how strain is transferred from one fault to another is open to debate, but parts of each of these three faults are creeping (Nason, 1971; Schulz and Burford, 1979).

Evidence of historical fault slip, other than creep, is rather sketchy. Lawson (1908, p. 434) reported that surface rupture occurred on the Hayward fault in 1868. He states that the line of surface rupture extended from near Warm Springs on the south, to the vicinity of Mills College in Oakland"... but the evidence of its existence to the northward of San Leandro is not very satisfactory." Displacement of eight to ten inches was generally reported, with a maximum reported displacement of three feet in Hayward. However, because Lawson's investigation was undertaken almost 40 years after the 1868 event, and because the data available to him were scanty, he was unable to determine the sense of displacement that occurred. Lawson does, however, describe afterslip in the Hayward area during the two weeks following the major shock (Lawson, 1908, p. 442).

Louderback (1947, p. 43) discovered an article in the Oakland Daily News (November 10, 1868) which stated in part, "There were large fissures in the earth [in 1868]... " and that "...the [1868] phenomena appear to have been a repetition of those observed in 1836, and noted by persons residing in the valley." The 1836 event was reportedly felt from San Pablo to Mission San

Jose. Louderback concluded, therefore, that faulting probably accompanied the 1836 event. Jennings (1975, and p.c.) relied on Louderback's conclusion and depicted the Hayward as historically active from Point Pinole southward to Warm Springs in 1836.

Russell (1926) concluded that the Hayward fault was a right-lateral strike-slip fault based on offset streams, sag ponds, and other fault-produced topographic features. He concluded (p. 511) that "...in the main, the displacement has been slow and by small steps...", based on the differences in amount of displacement apparent at different sites along the fault, but that larger 1868-like events have also occurred.

Buwalda (1929) briefly described the geologic evidence (principally the age and relative elevations of formations along the fault) for vertical displacement along the Hayward. However, he concluded (p. 195-196) that the most recent displacements have been almost entirely strike-slip. As evidence against major, recent, vertical offset, he cites the existence of an alluvial deposit which was at an elevation equal to that of Hamilton Gulch where it crosses the fault. This now-obliterated shutter ridge was located on the site of the U.C. Berkeley's Memorial Stadium.

Radbruch (1957) only briefly discusses the Hayward fault, principally discussing seismic data. Instead of showing a simple fault trace, she shows the fault as a zone 700 feet wide.

In 1966, several articles reporting fault creep along the Hayward were published. Radbruch and Lennert (1966a; 1966b) discussed damage to a culvert constructed in 1923 beneath Memorial Stadium. They reported that damage to the culvert was detected in 1948 and was repaired at that time. Further damage was detected in 1965. On both occasions, the damage observed was consistent with what would occur from fault creep. They (1966a) calculated a slip rate of 0.11 inches (0.28 cm) per year at this site. Bolt and Marion (1966) described their efforts to detect fault creep on the U.C. campus using creepmeters. However, their monitoring data covered the limited period of October 1965 to January 1966--not really long enough to do more than determine that fault creep was probably occurring during that period. Blanchard and Laverty (1966) reported that the Claremont water tunnel (in the Oakland East quadrangle) has been offset 17 cm since 1929. Thus, they documented fault slip averaging 0.46 cm per year, occurring over a 100-foot wide zone.

Nason, in his 1971 thesis on fault creep, reported that the U.S. Geological Survey had monitored fault creep at Memorial Stadium between 1966 and 1969. He reported a rate of 0.5 cm per year, suggesting either the rate of slip had increased or that the tunnel offset was actually greater than noted by Radbruch and Lennert. He also reported that surveys near 82nd Street and Golf Links Road (in the southern part of the Oakland East quadrangle) detected "changes indicating fault slippage," but presented no numerical data. The rates reported by Nason based on offset curbs and survey lines often slightly exceed 0.5 cm per year both north and south of the Oakland East and West quadrangles. For example, in the Parchester Village area of Richmond (north of the study area), he documents 11 cm of total displacement over a 20-year period (0.55 cm per year). He also reports similar rates of slip in Hayward to the south.

Case (1963) described several topographic features indicative of recent right-lateral slip along the Hayward fault. He concluded that, based on the straightness of the mapped traces, the fault plane must be steep-to-vertical in the Berkeley Hills area. However, he states, "Nowhere within the mapped area (of his thesis) has the fault plane been observed."

Radbruch (1967) made the first real attempt at a comprehensive study of the Hayward fault. The scale (1:62,500) of her 1967 map (which was largely a compilation of the work of others) lacked much of the detail of her (1968) 1:24,000-scale map. The latter map is annotated with limited descriptions of fault-related features (fault creep locations, sag ponds, etc.). A similar approach was used for Radbruch-Hall (1974, see Figure 3) which has some additions and deletions from earlier versions. In the Oakland East quadrangle, Radbruch (1967) reports fourth-hand that the 1868 fault rupture crossed the westerly end of the California School for the Blind. She places this zone of rupture west of the documented creeping trace. She also (1974) reports that the City of Oakland survey records indicate 4.4 cm of right slip occurred in the vicinity of Joaquin Miller Road and Interstate 580 between 1956 and 1964-65.

Radbruch (1969) infers several traces of the Hayward fault as cutting alluvium (her short dash symbol). In detail, these faults differ in location in several places from those shown on her 1974 map and occasionally they are shown interconnecting in different ways. (It appears that the base map of the Oakland East quadrangle used for her 1974 map had one component out of registration by about 125 feet. Comparisons were made between her 1974 map and two separate U.S.G.S. quadrangles of different vintage with similar results. When the maps are adjusted so that the cultural features are aligned, the topography does not match. When compared with her 1969 map, it appears the faults are plotted so that some segments align when the topography is matched, and other segments align when the cultural features match. Thus, her faults can only be shown on the Oakland East SSZ map as approximately located at best.)

Additionally, the explanation of fault symbols used varies significantly even though almost the same symbols were used to depict fault traces shown on her 1969 and 1974 maps. The 1969 legend states faults are:

> "Long-dashed where approximately located; short-dashed where inferred; dotted where concealed; queried where probable; double queried where hypothetical..."

This would seem to indicate that the queried traces are more likely to exist than the short-line trace. However, her 1974 legend implies the reverse:

> "Solid line, obvious photogeologic or field evidence of recent movement shown by scarp lines, trenches, sag ponds, offset streams, or gouge zones; short dashed line, less obvious evidence of recent movement, but very probably a fault break; queried where uncertain."

Her long-dash symbol is reserved for faults depicted by other authors, and does not indicate relative certainty. The data she presents on specific fault traces will be discussed below.

Herd (1978, see Figure 3) depicted fault-produced topographic features he observed on old aerial photographs (U.S.D.A., 1939). However, some of the features he depicts could have been produced partly or wholly by erosion if these features were near or on trend with harder data. In the Oakland East quadrangle, he shows fewer faults than does Radbruch-Hall in any of her versions (1968, 1969, and 1974), depicting instead a relatively narrow fault zone. Herd's data will be further discussed below.

Several consulting reports have been completed covering properties in the SSZ. The locations of these properties are shown on Figure 3, and the results are briefly summarized in Table 1. The techniques used by different consultants vary; thus the quality of the data are highly variable. Many of the reports consisted solely of a literature review and site reconnaissance.

These data, then, are those available along the Hayward fault. Below are discussed those data which apply to individual fault strands identified by letters A through K on Figure 3.

Fault segment A is the creeping segment identified by Radbruch and Lennert (1966a; 1966b), Brown (1970), Brown and Brekke (1980), Bolt and Marion (1966), and Woodward-Lundgren (1974, AP#13). Radbruch-Hall (1974), Herd (1978), and Buwalda (1929) all cite the existance of fault-produced topography along this trace. Radbruch (1969) depicts this strand as cutting Quaternary deposits. Segment A has not been trenched by any consultant. However, Lennert and Curtis (1980a; 1980b) were able to detect this fault, using seismic refraction, which they describe as a 100-foot wide shatter zone and a narrow eight-foot wide gouge zone.

Fault segment B is the site of the 1868 rupture as determined by Radbruch (1967), described in more detail above. Radbruch (1969) also shows this trace as cutting Quaternary deposits. Herd (1978) only detected several scarps along this trend, and differs from Radbruch-Hall (1974) as to the location of the fault strand at its northern end. In the Oakland West quadrangle, Radbruch (1957) shows the western limit of the Hayward zone to be somewhat east of segment B, and slightly west of the Louderback trace [which was determined to not be Holocene in FER-101 (Smith, 1980)]. Lennert and Curtis (1980a; 1980b) examined excavations dug for two structures along this fault trend and detected no faults. They believe the absence of such faults in older alluvium exposed in the excavations, along with the absence of fault-produced topography across the U.C. Campus and the School for the Deaf and Blind site, demonstrates the absence of the postulated recently active fault trace (segment B).

Fault segment C is depicted by Herd (1978) based on aligned scarps, truncated spurs, and a linear drainage. Radbruch (1969) also depicts a fault along this trend, but shows it as not cutting Quaternary alluvium. Woodward-Clyde Consultants (W.C.C.) (1976b, AP#206; 1977, AP#720) did not detect any active faults at a site where Herd depicts the fault as buried. W.C.C. did report evidence of fault creep just southwest of their site along the main zone of faults. Hillebrandt and Associates (1978, AP#808) and W.C.C. (1976a, AP#370) reported similar evidence further south along this zone (see Figure 3).

Radbruch-Hall (1974) recognized one right-laterally deflected drainage and a trough along segment D. Herd (1978) also recognized a series of scarps along the southern part of segment D (which he shows as buried). Of the consulting reports completed along this trace, Engeo (1977a, AP#538) found a highly complex zone of active faults about 80 feet wide. They documented two traces which reportedly cut soil horizons, and suspect that a third such trace exists. Just to the north, Hallenbeck-McKay and Associates (1978b, AP#911) found what they believed was a strand of the Hayward, however, the site had been graded prior to their investigation and the young, diagnostic materials removed. Further north still, Hillebrandt and Associates (1979, AP#973) detected and summarily dismissed an anomaly between two bore holes which were located about 20 feet from where they felt the active trace should be.

Herd (1978) depicts segment E based on aligned scarps. It appears that such a trace could conceivably exist as a branch of segment D, however, no other workers have identified these as fault-produced.

Segment F has been depicted by Herd (1978) and Radbruch-Hall (1974) based on aligned scarps and a linear trough. Engeo (1977a, AP#538) trenched this trace and detected a single fault which offset the soil, along with a second which did not affect the soil horizons. They also reported some evidence of fault creep.

Segment G has been shown by Radbruch-Hall (1974) and Radbruch (1969) in slightly differing fashions (see Figure 3). The 1974 version cites the existence of a scarp, and the 1969 version reports that Quaternary deposits are faulted. Herd (1978) did not detect any evidence of this trace. And various consultants have performed investigations along this trace and have failed to produce any evidence to support the existence of such an active trace. However, it should also be stated that these consultants have not trenched for the fault, and generally (verbally) point to the fault possibly existing under Wisconsin Street, or, at least, off the site then being investigated.

Segment H is also shown by Radbruch-Hall (1974; and 1969) with slight differences in location. One saddle is cited in the 1974 version, and Quaternary deposits are reportedly offset (Radbruch, 1969). Engeo (1979, AP#1004) detected a gouge zone which they treated as an active fault since the young materials had been disrupted by grading. Woodward-Clyde-Sherard and Associates (1966) state that the fault cuts alluvium, but their map does not identify the site where the observation was made. According to Levish (p.c.), the location of the displaced alluvium was south of the site investigated. Herd (1978) was unable to detect any recent fault features along this trend.

Segment I has been depicted as partly covered by landslide deposits by Herd (1978). Also reported along this trend are scarps, a notch (Herd), and a deflected drainage (Radbruch-Hall, 1974). Segments J and K shown by Radbruch-

Hall (1974 and 1969), were not detected by Herd (1978).

Peter Kaldveer and Associates (1975; map reference AP#157) identified at least three criss-crossing faults by projecting data from the logs of the BART tunnel, as well as by using seismic, magnetic, and bore hole data. They recommended a 50-foot setback from all three traces even though they lacked direct evidence of recent fault movement. However, this site is well east of any known active fault, outside the present SSZ.

For an evaluation of the creep evidence reported, see section 6 of this report.

6. Results of field investigation and air photo interpretation.

A careful check was made of all sites where fault creep has been reported, with the exception of the underground sites. Evidence for continuing fault creep was found only north of the Grove Shafter Freeway (State Route 24) along segment A and is summarized in Table 2. The sites reported by Woodward-Clyde (1976b) on Medau Place, and La Salle and Merced Avenues were checked. The bend of several inches could not be found, however, the curbs were broken and offset right-laterally slightly less than one inch. Some minor cracks were noted in adjacent structures, but no evidence of creep could be detected in the pavement of parking lots or streets. While the offset curbs could have been produced by fault creep, the lack of any fresh-looking or larger-magnitude evidence suggests that creep either is not now occurring at this location or is occurring at too low a rate to be detected.

Damage was also found at Redwood and Jordan Roads (Segment F) as reported by Engeo (1977a, AP#538); unfortunately, no other damage was detected in adjacent areas, suggesting that the damage may well be due to non-tectonic foundation problems. At all other sites where creep damage has been reported (Engeo,

TABLE 2. Description of Evidence for Fault Creep in the Oakland West (OW) and Oakland East (OE) Quadrangles (Refer to Figure 5)

OW-1	Narrow zone of left-stepping, en echelon fractures in pavement of Stadium Rimway (B+ quality). *
OW-2	At north end of Memorial Stadium near first-aid station and Stadium business office, an old abandoned stairway shows evidence of cracking and shortening. End of metal railing misses spot where it used to connect to foundation by a few inches. Stairway concrete shows evidence of similar displacement (right-lateral) (B quality).
OE-1	Culvert under Memorial Stadium offset (Radbruch & Lennert, 1966a; 1966b)
OE-2	Zone of cracking in pavement and sidewalks adjacent to apartment house on Dwight Way; crack zone on trend with fault, but no left-stepping pattern detected (C quality).
OE-3	Sidewalk extension of Derby Street appears to be right-laterally offset (C quality).
OE-4	Sidewalk right-laterally offset at #91 Stonewall; left-stepping en echelon fractures in street pavement in a narrow zone trending to the southeast; structure appears to be racked.
OE-5	Left-stepping en echelon fractures in street pavement.
OE-6	Curb cracked and possibly and possibly overthrust (sites OE-4 through OE-6) (A quality).

* The quality ratings consider the level of certainty, type and magnitude (relative to background "noise") of the fault creep data. "A" quality sites are those where virtually all man-made features show the effects of fault creep, and two or more types of evidence (e.g., offset curbs and left-stepping en echelon fractures in pavement) support fault creep. "B" quality sites are those where one or more of the above factors is absent. For example, a site where one curb is offset, some en echelon fractures are observed, but the other curb is not offset would be a "B" quality site. "C" quality sites are those where only one line of evidence is present. For example, a locality having one offset curb (if the offset is significantly larger than the background "noise") would be a "C" quality site.

TABLE 2, Continued

OE-7	Claremont Water Tunnel site (Blanchard and Laverty, 1966a; 1966b)
OE-8	BART Tunnel site (Brown, 1970); minor left-stepping fractures in pavement of Tunnel Road.
OE-9	Severely cracked pavement of Highway 24 offramp (C quality).
OE-10	Broadway Terrace offramp from Highway 13, left-stepping en echelon fractures in pavement (B quality).
OE-11	At corner of Broadway Terrace and Pinewood Road, curb appears to be offset right-laterally, other curb appears to be buckled. Freeway overpass adjacent has curb alongside it which appears to have been pulled apart (C quality).
OE-12	Curbs on both sides of Medau Place appear to be right-laterally offset about one inch (C quality).
OE-13	Curbs on both sides of La Salle Avenue appear to be right-laterally offset about one inch (C quality).
OE-14	Curb on Merced appears to be right-laterally offset. Curb at corner of Antioch Street and Moraga appears to be buckled (compression). Offsets observed at sites OE-12 through OE-14 are aligned (B quality).

1977a, AP#538; Hillebrandt & Associates, 1978, AP#808; and Woodward-Clyde Consultants, 1976a, AP#370) either the evidence was not found or was determined to have probably resulted from other causes. In the case of the City of Oakland survey cited by Radbruch-Hall (1974, shown on Figure 3), the deflections in survey lines could have been the result of strain build-up; no clear evidence of creep has yet been found.

Two sets of aerial photographs covering the entire fault zone addressed in this report were interpreted. In the Oakland East quadrangle, the data derived from the U.S.D.A. (1939) air photos were plotted on a 1949 topographic base primarily because of the extensive modification of the landscape that occurred during construction of the Warren Freeway. These data were then carefully traced onto an overlay and composited with the more recent topographic base (see Figure 4). Data from more recent photos were plotted directly onto the newer base.

In the northern half of the study area, along segment A, the Hayward fault trace is well-defined by deflected drainages, scarps, linear troughs and other geomorphic features associated with recently active right-lateral faults. In the southern half of the study area, the zone is less well-defined. Indeed, it appears that more than one active trace may exist. There appears to be a slight bend in the fault in this area, and several low, linear hills are present within the fault zone. In general, the fault-produced topographic features in this area are less well-developed and are more discontinuous suggesting that fault slip may be distributed, with total displacement along any one trace being significantly less than that measured to the north and south (as reported by Nason, 1971).

Several features observed on the air photographs coincided with those depicted by Herd (1978). However, my interpretations differ significantly from Herd in two areas. North of the Grove Shafter Freeway, Herd interprets several scarps in bedrock as resulting from recent fault movement along a westerly branching trace (segment B). However, it appears likely that these scarps are erosional in nature, probably an ancient stream channel which has been breached in two places. Also, there are no features visible in the alluvial areas that suggest the existence of a recent fault. In essence, all of the northeastern-facing escarpments north of the Grove Shafter, and the southwestern-facing escarpment along Ashby Avenue are probably the remains of this ancient drainage. Thus, the active Hayward fault appears to be a very narrow (100-200 foot $\pm$ in width), though not necessarily straight, zone between Diamond Canyon and the U.C. campus. The easterly branch depicted by Herd in the vicinity of Joaquin Miller High School (segment C) also appears to be erosional. And, a stream did not appear to be offset just south of the scarps noted by Herd (segment E), suggesting the large scarps are probably not a product of movement along any throughgoing fault.

Radbruch (1969) depicts several fault traces in the southern half of the study area as cutting Quaternary deposits, and she also shows these on her 1974 map as well. However, neither Herd (1978) nor the author was able to detect any features (other than saddles, tonal lineaments, or other features which are commonly the manifestation of other than recent faulting) indicative of recent faulting. In general, there are five such "faults", one generally along Wisconsin Street in Oakland (segment G), one generally along MacArthur Boulevard (segment K), one along the MacArthur Freeway (segment D), and another close to the latter, but shown near Oak Knoll Naval Hospital and

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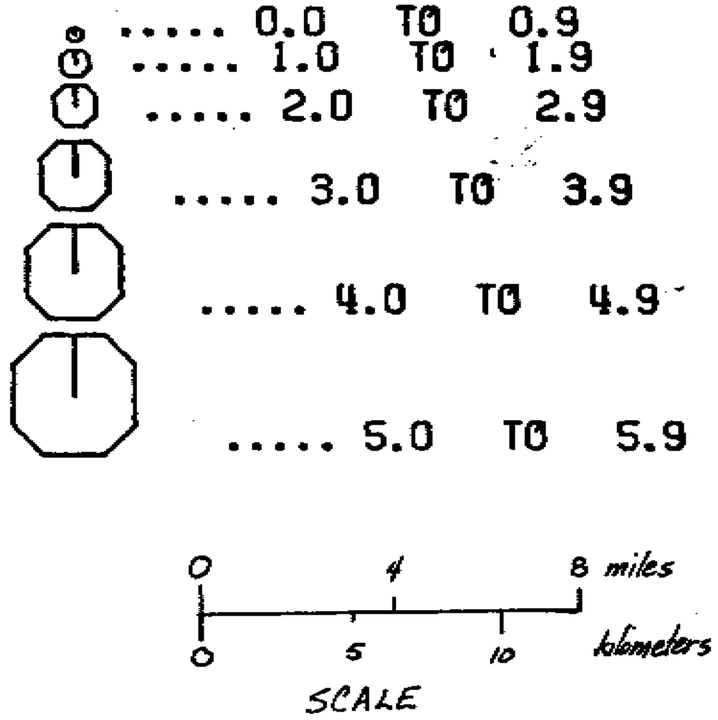
EARTHQUAKE EPICENTERS 1900-1974

OF A QUALITY ACCORDING TO CATALOG SOURCE
EARTHQUAKE CATALOG EDITION I
CALIFORNIA DIVISION OF MINES AND GEOLOGY

TRANSVERSE MERCATOR PROJECTION

SCALE = 1/250000

MAGNITUDE



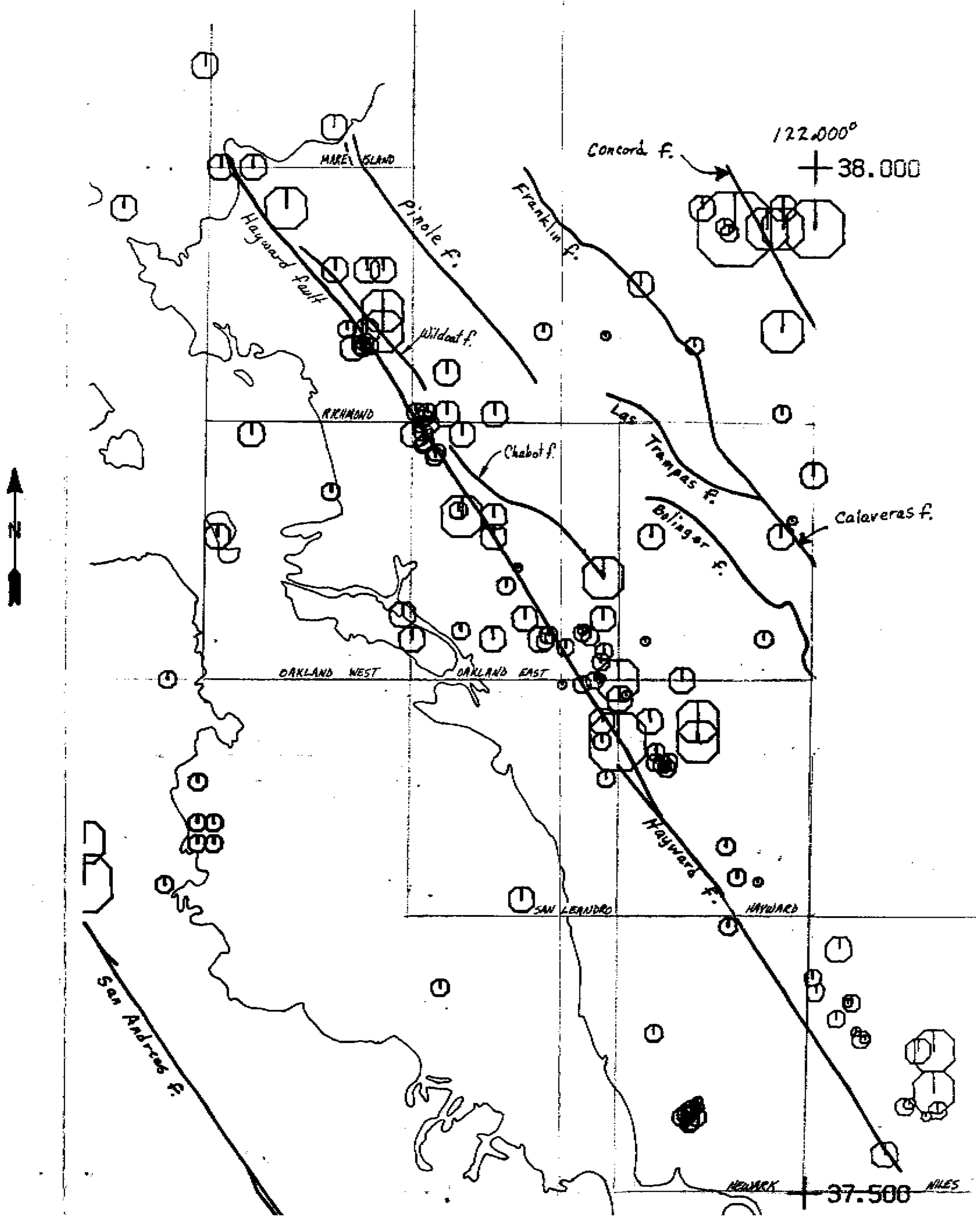


Figure 7. Locations of "A" quality earthquake epicenters in the vicinity of the Hayward fault from Point San Pablo to Niles (after Real, et al., 1978) and principal faults in the area.

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through Knowland State Arboretum (segment H). With respect to the latter, in spite of the Woodward, Clyde, Sherard (1966) map noting that alluvium is offset (see Figure 3), a small ridge through which they show the fault as passing, shows neither any offset nor even any "soft" data (tonal lineaments, topographic lows, etc.). Similarly, the two creek drainages on either side of the ridge show no evidence of deflection strongly suggesting the fault is pre-Holocene. Only the aligned saddles noted by Radbruch-Hall (1974) and some tonal lineaments in these saddle were visible on the photographs to indicate that a through-going fualt may exist along this trend (but not necessarily an active fault). No stronger evidence exists to the south (in the area addressed in FER-103). And finally, no features were found along segment J to support its being active.

7. Seismicity.

The Hayward fault has long been documented as seismically active. As noted earlier, major earthquakes occurred in 1868 (Lawson, and others, 1908) and 1836 (Louderback, 1947). Real, et al. (1978, see Figure 7) have documented a zone of seismicity along the Hayward fault.

8. Conclusions.

That the Hayward fault is seismically active has been demonstrated. The literature also provides sufficiently detailed descriptions to document surface fault movement during 1868 (Lawson, and others, 1980) and fault creep in some areas (Nason, 1971; Radbruch-Hall, 1974). However, investigators differ on just where the active traces of the Hayward fault are located, and just how many such traces exist. In the study area, those workers principally relying on aerial photographs (Herd [1978], and this report) tend to agree with many of the consulting geologists that the active traces occur along one or two fairly narrow trends (segment A, F, I and possibly the northern part of D). The zone appears to be narrow and well-defined in the northern half of the study area, and more complex, but still fairly well-defined in the southern half. Certainly the creeping trace is active.

As noted earlier, Radbruch-Hall (1974) appears to have relied heavily on her earlier work and appears to have been reluctant to omit any of her possible branches of the Hayward even though several lacked good evidence of recent activity. Also, some of her traces imply that these faults have a continuity that may not be real. Herd (1978) appears largely to have identified recent faults, but in some cases, he probably has identified erosional features as possible active branches of the Hayward (segments B, C, E, and the southern part of D). His suggestion that the fault creep reported at the U.C. Memorial Stadium may be due to other causes appears to be erroneous because the magnitude and sense of the displacement observed is consistent (over the long term as well as short term) with that observed along the Hayward fault north and south of the study area.

Engeo (1977a, AP#538) documents the existence of two active zones of the Hayward fault near the Golden Gate Academy (segments D and G). Except for the faults detected in Engeo's report, no unequivocal evidence of recent faulting has been reported by consultants in the Alquist-Priolo investigations filed with the State Geologist. Neither has unequivocal evidence of the absence of any of Radbruch-Hall's (1974) or Herd's (1978) postulated faults been submitted. In fact, it appears that many of the consultants, the reviewers, and the clients in the area are quite often content to point to a published map, check the available air photos, and conclude where the fault does or does not lie.

Therefore, it appears the best available information consists of combination of fault creep data, air photo data (Herd, 1978; and this report), and trench data (primarily Engeo, 1977a, AP#538). However, it is recognized that the absence of creep does not demonstrate the absence of an active fault.

9. Recommendation.

The Special Studies Zones along the Hayward fault in the area studied should be revised as shown on Figure 5. These traces are compiled from Herd (1978), Radbruch-Hall (1974), and Smith (this report). By no means, however, should all of the faults depicted by Radbruch-Hall and Herd be zoned (see above sections for discussion). The fault traces shown on the SSZ maps should be based on topographic features which are clearly the result of recent (Holocene) faulting. Permissive data should be included only when aligned with the more definitive evidence.

All fault traces shown on the 1974 Special Studies Zones maps of the Oakland East and Oakland West quadrangles that do not coincide with those shown on Figure 5 should be deleted. The SSZ boundaries should be drawn approximately as depicted on Figure 5.

10. Principal investigator; date.

I agree with recommendations shown on Fig. 5. Do not use questionable creep data on SSZ map, however. EWH 2/16/81

Theodore C. Smith
THEODORE C. SMITH
Associate Geologist
RG 3445, CEG 1029
December 15, 1980

TCS/clz

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Table 1. Summary of results of consultants' investigations.

CDMG FILE NUMBER	AUTHOR & DATE	METHODS USED: Trenching	Seismic Refraction	Other Methods*	Air Photo Interpretation	Visit Site	Literature Review	Was active fault found?	Comments
AP 13	Woodward-Lundgren & Assoc, 1974				XX	XX	XX	No	Fault creep reported on Tunnel Road.
AP 16	Curtis, 1974	XX				XX	XX	No	
AP 96	Lowney-Kaldveer Assoc, 1975			M	XX	XX	XX	No	
AP 157	Kaldveer & Assoc, 1975			BH, M		XX	XX	Yes/?	3 "cross faults" identified as possible site of secondary rupture; (lacks definitive age data)
AP 166	Hillebrandt Assoc, 1975					XX	XX	No	
AP 176	Western Geological Consultants 1975					XX	XX	No	
AP 206	Woodward-Clyde Consultants, 1976b	XX			XX	XX	XX	No	Fault creep reported nearby.
AP 325	Western Geological Consultants 1976a					XX	XX	No	
AP 369	Hallenbeck-McKay & Assoc, 1976				XX	XX	XX	No	
AP 370	Woodward-Clyde Consultants, 1976a				XX	XX	XX	No	Creep reported adjacent to site.
AP 371	Rhoades & Assoc, 1975		XX	BH	XX	XX	XX	No	
AP 372	Purcell, Rhoades, & Assoc, 1976	XX				XX	XX	No	
AP 373	Western Geological Consultants 1976b				XX	XX	XX	No	

*M= magnetometer; G= gravity; BH= bore hole correlation; TP= test pits

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Table 1 (cont).

CDMG FILE NUMBER	AUTHOR & DATE	METHODS USED: Trenching	Seismic Refraction	Other Methods*	Air Photo Interpretation	Visit Site	Literature Review	Was active fault found?	Comments
AP 452	Western Geological Consultants 1977a				XX	XX	XX	No	Reports damage on Norton AVe. (Fault creep?)
AP 506	Hillebrandt & Assoc, 1977b			BH	XX	XX	XX	No	
AP 507	Western Geological Consultants 1977b				XX	XX	XX	No	
AP 538	Engeo, 1977a	XX	XX	M, BH	XX	XX	XX	Yes	Two active zones detected; soil offset by both; fault creep evidence reported.
AP 562	Engeo, 1977c				XX	XX	XX	No	
AP 718	Engeo, 1978	XX			XX	XX	XX	No	
AP 719	Engeo, 1977b	XX			XX	XX	XX	No	
AP 720	Woodward-Clyde Consultants 1977				XX	XX	XX	No	
AP 722	JCP-Geologist, 1978b				XX	XX	XX	No	
AP 808	Hillebrandt & Assoc, 1978	XX	XX	TP	XX	XX	XX	No/?	No faults in trench, butactive fault may cross property, not building site.
AP 813	Hallenbeck-McKay & Assoc, 1978a	XX			XX	XX	XX	No	ditto
AP 814	JCP-Geologists, 1978c	XX			XX	XX	XX	No	
AP 815	Zickefoose & Assoc, 1978	XX			XX	XX	XX	No	

*M= magnetometer; G= gravity; BH= bore hole correlation; TP= test pits

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CDMG FILE NUMBER	AUTHOR & DATE	METHODS USED: Trenching	Seismic Refraction	Other Methods*	Air Photo Interpretation	Visit Site	Literature Review	Was active fault found?	Comments
AP 816	Earth Science Consultants, 1977			BH, TP	XX	XX	XX	No	
AP 856	Western Geological Consultants 1978				XX	XX	XX	No	
AP 883	Logistics Internatonal Cons. 1978a	XX			XX	XX	XX	No	
AP884	JCP-Engineers & Geologists 1978			BH	XX	XX	XX	No	
AP 885	Soares & Assoc, 1978			BH	XX	XX	XX	No	
AP 886	Logistics International Cons. 1978b	XX				XX	XX	No	
AP 910	Hillebrandt & Assoc, 1977a			BH	XX	XX	XX	No	
AP 911	Hallenbeck-McKay & Assoc, 1978b	XX		BH	XX	XX	XX	Yes/?	Diagnostic material graded off prior to trenching. NO conclusive evidence for or against activity.
AP 970	JCP-Geologists, 1978d				XX	XX	XX	No	
AP 971	Hallenbeck-McKay, 1979			BH	XX	XX	XX	No	
AP 972	Georesource Consultants, 1979	XX			XX	XX	XX	No	
AP 973	Hillebrandt Assoc,1979		XX	BH	XX	XX	XX	No	
AP 974	Lowney & Assoc, 1979			BH	XX	XX	XX	No	

*M= magnetometer; G= gravity; BH= bore hole correlation; TP= test pits

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CDMG FILE NUMBER	AUTHOR & DATE	METHODS USED: Trenching	Seismic Refraction	Other Methods*	Air Photo Interpretation	Visit Site	Literature Review	Was active fault found?	Comments
AP 984	Hallenbeck-McKay & Assoc, 1977	XX	XX	BH	XX	XX	XX	No	
AP 986	PSC Assoc, 1976	XX		TP, BH		XX	XX	No	
AP 1003	Logistics International Cons. 1979	XX			XX	XX	XX	No	
AP 1004	Engeo, 1979	XX		TP	XX	XX	XX	Yes/?	Gouge zone treated as an active fault; not exposed in trench.
AP 1005	Kaldveer & Assoc, 1979	XX			XX	XX	XX	No	
AP 1069	Western Geological Consultants 1978	XX			XX	XX	XX	No	
AP 1070	Purcell, ~~Rhoades, & Assoc,~~ 1979			BH		XX	XX	No	
AP 1209	Western Geological Consultants 1980								Same as AP 452 with letter attached.
AP 1210	Merrill & Seeley, 1980				XX	XX	XX	No	
C 332	Western Geological Consultants 1978	XX	XX	M	XX	XX	XX	No	
C ~~7~~4 61	Lennert & Curtis, 1980a		XX	BH	XX	XX	XX	Yes	Single active trace found; other faults not active.
C ~~7~~4 62	Lennert & Curtis, 1980b		XX	BH	XX	XX	XX	Yes	Ditto. Essentially the same report as C 761.

*M= magnetometer; G= gravity; BH= bore hole correlation; TP= test pits